CDM

Butte County Department of Water and Resource Conservation

Integrated Water Resources Program

Urban Water Demand Forecast

October 2003

Technical Memorandum

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Section 1 - Introduction

1.1 Project Description

This technical memorandum (TM) describes an urban water demand forecast for the Butte County Integrated Water Resources Program (Program). *The Program is intended to improve water management in the County and to maintain agricultural viability, meet urban and environmental needs, ensure a future groundwater supply to overlying users, enhance the economy, and protect the citizens and natural resources of Butte County.*

As part of the Program, Butte County will develop:

- Basin Management Objectives
- Water Demand Forecasts
- An Environmental Monitoring Plan
- A Drought Preparedness Plan
- An AB 3030 Groundwater Management Plan
- An Integrated Watershed and Resource Conservation Plan
- An Updated Conservation Element of the County General Plan

Butte County seeks to develop these plan elements through an inclusive process that informs, educates, and involves local stakeholders.

Stakeholders in Butte County understand the value of their water resources and have been proactive in advancing water management through groundwater modeling, monitoring and cataloging of the resource. Development and implementation of the Program will benefit from the active participation of those who have knowledge of – and a stake in – the outcome of the planning process. Locally driven Program development will contribute to plan elements that are appropriate, equitable, and implementable.

1.2 Project Context

The California Department of Water Resources (DWR) is providing funding for Program development through a study grant to Butte County. Butte County's Department of Water and Resource Conservation (Department) is leading the planning effort. The Department, which the County established in 1999, prepared the

County's *Water Inventory and Analysis Report* (released in March 2001). DWR's Division of Planning and Local Assistance also provided funding for the *Water Inventory and Analysis Report.* The County is working with a Study Team comprising Camp Dresser and McKee, Inc. (CDM); California State University, Chico; and Cotton•Bridges•Associates.

1.2 Purpose and Scope

The purpose of the demand forecasts described in this TM is to provide data useful for the formulation of recommended policies as part of the Program. Describing the existing and forecasted settings for which the plan is being developed is an early step in the integrated planning process. These forecasts help to predict the County's situation in the future. Using these forecasts, the Study Team can describe the County's future urban water needs and, through the planning process, develop and evaluate potential actions that can address the planning objectives, which include meeting the County's water needs.

These forecasts were prepared for Butte County specifically, and include water demand estimates for 2000, 2010, 2020, and 2030. As described in this TM, this forecast is intended for use at the countywide level.

1.3 Document Overview

This TM describes the model selection and forecasting method (Section 2); the input sources and development (Section 3); and the findings of the forecasts (Section 4). A separate TM (TM 4-2) describes forecasts made for Countywide agricultural water demand as part of this effort.

Section 2 – Model Selection and Forecasting Method

This section introduces the model and method selected for this analysis (Section 2.1) and presents the basic equation employed (Section 2.2). Section 2.3 - 2.8 discuss analysis units, model input, and the variables used in the basic equation. Section 2.9 presents an example calculation.

2.1 Model Selection

The IWR-MAIN Water Demand Management Suite© was selected to perform the urban water demand forecast. This software is a state-of-the-art, easy to use, flexible, and powerful suite of tools for forecasting water demand and is a standard in the industry. The selected forecasting method is IWR-MAIN's *adjusted rate of use* method. This method is consistent with those used by the California Department of Water Resources (DWR) for development of the *California Water Plan Update* (Bulletin 160-03), a statewide planning effort. Furthermore, this method is appropriate for the level of data available for this analysis.

2.2 Forecasting Method

The *adjusted rate of use* forecasting method calculates the quantity of water use in a given subsector for a specified forecast year.

The water use for a subsector is the product of the number of counting units in the subsector, a per unit water use rate, and a series of adjustment factors derived from selected explanatory variables. This analysis employs average daily use rates to calculate water demand in gallons for a given month in the forecast year for each subsector according to the following formula:

$$Q_{s,m,y} = N_{s,m,y} \cdot q_{s,m,b} \cdot \Pi \left(\frac{X_{j,s,m,y}}{X_{j,s,m,b}} \right)^{\beta_{j,s,m}} \cdot d_m \qquad \text{[Eq. 2.1]}$$

where:

Q = Gallons of water used in subsector *(s)* in month (m) in year *(y)*

N = Number of units in subsector (s) in month (m) in year (y)

q = Average daily water use rate per unit in subsector (s) in month (m) in base year (b)

Xb = Value of explanatory variable (j) in base year (b)

Xy = Value of explanatory variable (j) in year (y)

β = Elasticity of per unit water use rate for variable (j) in subsector (s) in month (m)

d = Number of days in month (m)

This method was employed to provide forecasts for the study area. Sections 2.3 and 2.4 below discuss the units of analysis to which this formula was applied.

2.3 Study Areas

A study area is a defined geographic unit such as a city, service area, county, or watershed. This analysis further divides the study areas into sectors and subsectors for forecasting with the *adjusted rate of use* method. A sector is a class of water users, such as residential housing units, and a subsector is a subclass of water users, such as single-family housing units. Section 2.5 discusses sectors and subsectors.

For this analysis, geographic areas with similar water use rates were grouped into study areas. This analysis delineates six study areas in Butte County: Biggs, Chico, Gridley, Oroville, Paradise, and the remaining unincorporated areas. Figure 2-1 shows the study areas. The incorporated areas represent approximately 50 percent of the population of the county, while the unincorporated areas represent the remainder. Estimating water demand for incorporated areas provides information of interest to the County, cities, and water purveyors. Census data used as inputs into the water demand models are readily obtainable by city and by county. For reporting, IWR-MAIN can aggregate the results of any combination of the study areas.

Definitions:

Study area = defined geographic unit (e.g., a city or watershed)
Sector = a class of water users (e.g., residential housing units)
Subsector = subclass of water users (e.g., single family housing units)

Water purveyors and the DWR public water system statistics database were the sources for study area water use data. Table 2-1 lists the population and major water purveyors for each study area. In general, the boundaries of the water purveyors match the boundaries of the study areas that they serve except in Oroville and the unincorporated areas. Oroville receives water from three water purveyors whose service area borders are partially inside and partially outside of the incorporated area boundary. The unincorporated areas of the county are served by several urban water purveyors (not listed) and by a significant number of private wells.

Table 2-1
Water Purveyors of Forecast Model Study Areas

Study Area	2,000 Census Population	Water Purveyor
Biggs	1,799	City of Biggs
Chico	59,444	California Water Service Company, Chico
Gridley	5,450	City of Gridley
Oroville	12,969	California Water Service Company, Oroville
		Oroville Wyandotte Irrigation District
		Thermalito Irrigation District
Paradise	26,451	Paradise Irrigation District
Unincorporated Areas	97,058[1]	Several Water Purveyors *(not listed)*
		Private Wells

[1]Estimated as population of incorporated areas subtracted from population of the entire county.

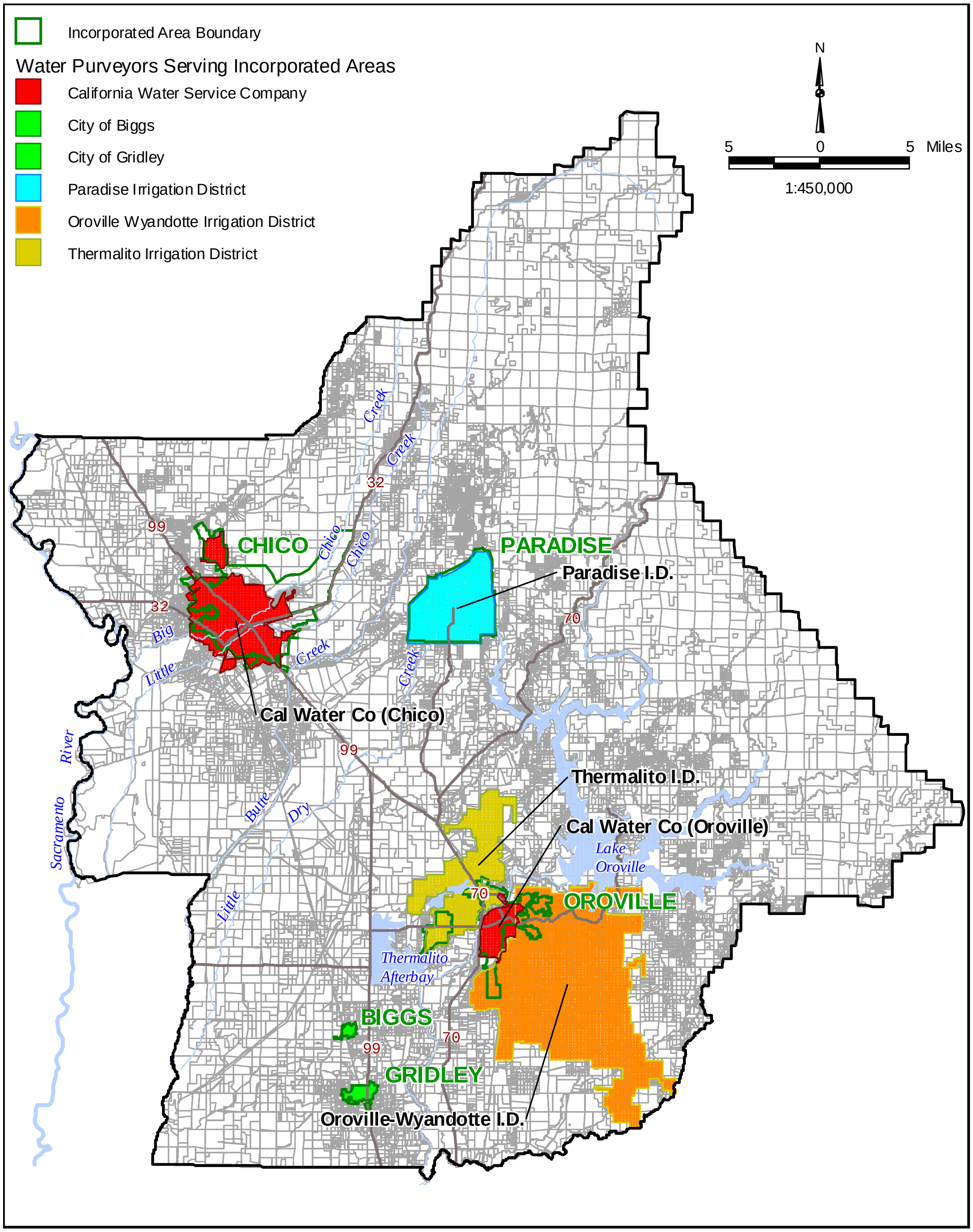

Figure 2-1
Boundaries of Water Purveyors and Incorporated Areas

2.4 Sectors and Subsectors

A sector is a group of water users with similar water use characteristics. This analysis estimates water demand independently by two sectors, residential and nonresidential. Similarly, each sector has subsectors (Table 2-2). Although not a true sector, the unmetered/unaccounted water use category is also included in the water demand estimate for each study area.

Table 2-2
Model Sectors and Subsectors

Sector	Subsector
Residential	Single-Family
	Multifamily
Nonresidential	Commercial
	Industrial
	Large Landscape

2.5 Forecast Years and Base Year

This analysis forecasts water demand for the years 2010, 2020, and 2030. To make these forecasts, the *adjusted rate of use* method draws on one year of historical water use data, called the base year, for input. The base year of this forecast is 2000. The forecasts use this base year and the number of base year counting units, as well as a projection of future counting units (see below), to project the water demand for each subsector. For future years, this calculated rate of use is adjusted to reflect the difference between the base year and future year values of the explanatory variables.

2.6 Counting Units

A counting unit represents a water user, or set of users, for which a per unit water use rate may be calculated. Counting units for this analysis include numbers of people, jobs, and housing units. As illustrated in Equation 2.1, the number of counting units (N) is multiplied by the per unit water use rate (q) to derive the water use for a subsector. Table 2-3 lists the counting units selected for each subsector in this study.

Table 2-3
Model Counting Units

Sector	Subsector	Counting Unit
Residential	Single-Family	Single-Family Housing Units
	Multifamily	Multifamily Housing Units
Nonresidential	Commercial	Commercial Jobs
	Industrial	Industrial Jobs
	Large Landscape	Population, in 1000's

2.7 Explanatory Variables

An explanatory variable (X in Equation 2.1) is a variable that has an effect on the value of the per unit water use rate, such as the average daily maximum temperature during a month. (As the temperature increases, so typically does the per unit water use rate.) The model uses explanatory variables to adjust the base year per unit water use rates. Table 2-4 lists the explanatory variables selected for this analysis.

Table 2-4
Model Explanatory Variables

Sector	Explanatory Variable
Residential	Median Income (Year 2000 Dollars)
	Housing Density (Units per Acre)
	Persons per Household
	Marginal Water Price ($)
	Average Daily Maximum Temperature (°F)
	Precipitation (Inches)
Nonresidential	Marginal Water Price ($)
	Average Daily Maximum Temperature (°F)
	Precipitation (Inches)
	Cooling Degree Days (°F)

2.8 Elasticities

As illustrated in Equation 2.1, the model uses elasticities (β) to determine the influence of each explanatory variable on the per unit water use rate. Each explanatory variable is raised to the power of an elasticity (β), which is a constant for each explanatory variable and is a measure of the sensitivity of the per unit water use rate to the change in the explanatory variable. For example, if the marginal price of water increases by 10 percent compared to the base year and the elasticity for marginal price is -0.1, then the per unit water use rate will decrease by approximately 1 percent. There is one elasticity value for each explanatory variable for each subsector.

2.9 Example Calculation

Equation 2.2 below shows an example calculation utilizing the *adjusted rate of use method* (illustrated generically in Equation 2.1). This example forecasts monthly water use for the single-family subsector for July in the year 2010. The number of projected single-family housing units (counting units) in the study area in year 2010 is 1,900 units. The base year (year 2000) per unit water use rate for July is 500 gallons/day. The explanatory variables are marginal price and average daily maximum temperature. In year 2010, the marginal price is $0.75 and the average daily maximum temperature is 92 °F, compared to the base year, in which they are $0.63 and 89 °F, respectively. The elasticity for marginal price is –0.1 and the elasticity for average daily maximum temperature it is 0.97.

In this example, the base year per unit water use of 500 gallons per day per unit is adjusted to 507 gallons per day given the change in marginal price and temperature.

$$Q_{SF,\,July,\,2010} = (1900 \text{ single family units})\,(500 \text{ gallons/day/single family unit})$$

$$\left(\frac{\$0.75}{\$0.63}\right)^{-0.1} \cdot \left(\frac{92\ °F}{89\ °F}\right)^{0.97} \cdot (31\ days) \qquad \text{[Eq. 2.2]}$$

Section 3 – Input Sources and Development

3.1 Base Year Water Use

As described in Section 2, the forecasting model uses one year of historical water use data, called the base year, for input. The primary sources of historical water use data for this analysis were the public water system statistics collected by DWR, shown for the applicable water purveyors in Appendix *A*. The three main pieces of information available from DWR were the active service connections, the total water into the system, and the metered water deliveries.

- The **active service connections** are the number of metered and unmetered water user accounts listed by subsector.

- The **total water into the system** is the amount of water produced at the source of the water purveyor's supply. Total water into the system is measured before any losses in the conveyance system occur and includes water that will be delivered to unmetered accounts.

- The **metered water deliveries** are the amounts of water delivered to metered water use accounts listed by subsector. These deliveries are measured after conveyance losses have occurred in the system and do not include any water use for unmetered accounts.

Year 2000 water use data for the water purveyors in the county were obtained from the DWR Public Water System Statistics (PWSS) survey. Some of the data were not available or were contradictory to other data sources. For example, some data were not available for unmetered accounts. Some discrepancies occurred due to misinterpretation of DWR water use categories by the water purveyors. To fill in missing data and to obtain reasonable results, CDM made some assumptions about and adjustments to the DWR water use data. Adjustments were made based on study area information obtained through interviews with water purveyors and based on typical values for the county and for the water industry as a whole, as described in Sections 3.1.1 -3.1.6 below.

3.1.1 Biggs Base Year Water Use

Table 3-1 shows the base year monthly water use as entered into the IWR-MAIN model for Biggs, which is served by the City of Biggs. The data in Table 3-1 is based on DWR PWSS and on typical water use rates in the county. Table *A*-1 in Appendix *A* shows the DWR PWSS for year 2000 for the city of Biggs.

Table 3-1
Base Year (2000) Water Use for Biggs in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	3.85	3.88	7.44	7.59	13.10	15.93	15.31	12.58	8.81	10.43	5.78	4.06
Multifamily	0.36	0.42	0.69	1.86	1.23	1.75	1.48	1.35	1.30	0.97	0.63	0.42
Commercial	0.67	0.68	0.71	1.02	1.33	1.63	1.87	1.86	1.75	1.46	1.13	0.76
Industrial	0.47	0.38	0.40	0.50	0.58	0.60	0.56	0.62	0.53	0.45	0.50	0.47
Lg. Landscape	0.00	0.00	0.02	0.07	0.03	0.06	0.13	0.18	0.19	0.31	0.11	0.01

As the data in Appendix A illustrates, Biggs has no metered water user accounts and monthly water use is not directly available for any of the subsectors. Therefore, per unit water use rates from other water purveyors were assumed for Biggs. The per unit water use rates for the single-family and multifamily subsectors were assumed to be the same as those of Gridley. For the commercial, industrial, and large landscape subsectors, the per unit water use rates were assumed to be the same as those of Chico.

The monthly base year water use for Biggs was calculated by multiplying the assumed per unit water use rate for each month by the counting units for Biggs. For example, the following equation was used for the Biggs single-family subsector in January:

$$Q_{January,Biggs} = N_{SF,Biggs} \times \frac{Q_{January,Gridley}}{N_{SF,Gridley}} \qquad \text{[Eq. 3.1]}$$

where:

Q = Gallons of water used for the single-family subsector in January of the base year

N = Number of single-family housing units in a particular study area in the base year

These estimated monthly water use amounts were then adjusted so that the total water use for Biggs across all sectors plus the estimated system water losses equaled the total water into the system from the DWR PWSS. Based on an interview with the city's consultant,[1] the value of 399.5 million gallons of water in Table *A*-1 is incorrect for year 2000 (Swartz 2003). The consultant provided a revised value of 186 million gallons into the system, total, which includes an estimated 23 percent conveyance loss (Swartz 2003). The residential and nonresidential water use models were adjusted such that the total water use (including losses) for the base year equaled 186 million gallons. For this adjustment, the monthly water use rates estimated from the Gridley and Chico data were increased by 14 percent for all subsectors.

[1] David Swartz of California Engineering

3.1.2 Chico Base Year Water Use

Table 3-2 shows the base year monthly water use as entered into the IWR-MAIN model for Chico, which is served by the California Water Service Company (Cal Water). The data in Table 3-2 is based on DWR PWSS and on information provided by Cal Water. Table *A*-2 in Appendix *A* shows the DWR PWSS for year 2000 for Chico. The base year water use for the commercial and industrial subsectors was obtained directly from these PWSS. Single-family, multifamily, and large landscape subsector data are based on both the PWSS and information obtained from interviews with Cal Water, as described below.

Table 3-2
Base Year (2000) Water Use for Chico in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	124.39	123.75	127.23	229.66	286.39	412.34	489.28	483.31	440.09	314.42	222.02	144.83
Multifamily	61.60	64.91	63.70	80.23	101.19	119.55	127.04	128.88	128.28	106.23	87.14	67.48
Commercial	97.48	99.24	103.39	148.73	193.19	237.56	272.34	270.14	254.87	212.72	164.79	110.42
Industrial	9.69	7.73	8.22	10.17	11.90	12.37	11.40	12.68	10.86	9.17	10.24	9.63
Lg. Landscape	0.12	0.14	0.44	1.94	0.76	1.87	3.68	5.21	5.39	8.87	3.12	0.14

Adjustments were made to the monthly water use data for the single-family and multifamily subsectors. Cal Water serves areas of the greater Chico area that are outside of the incorporated boundaries, and the DWR PWSS data includes water use in those areas. Therefore, per unit water use rates were developed from the PWSS data for the metered accounts and applied to the housing units in the incorporated boundaries. This approach is based on the assumption that per unit water use rates are similar inside and outside the incorporated boundaries.

For the single-family subsector, an average per unit water use rate of approximately 580 gallons/day/unit was calculated for the 2000 data by dividing the number of metered accounts into the metered water use. In its own water demand forecast report, Cal Water reported a similar value of 570 gallons/day/unit for metered accounts for 1999 (California Water Service Company, 2002). Cal Water also reported a much higher per unit water use rate of 800 gallons/day/unit for unmetered accounts for 1999. Weighting these per unit water use rates by metered and unmetered accounts yields an average rate of 715 gallons/day/unit. From these 1999 data, the ratio of average to metered per unit water use rates was 1.25. This factor was multiplied by the year 2000 monthly per unit water use rates to obtain overall monthly per unit water use rates, which resulted in an annual per unit use rate of 725 gallons/day/unit.

These monthly per unit water use rates were multiplied by the number of single-family housing units from the 2000 demographic data to obtain the base year monthly water use totals shown in Table 3-2.

Since the early 1990's, new housing units in Chico have been required to have water meters. Therefore, the percentage of unmetered accounts will decrease over time, and the overall single-family weighted average per unit water use rate will decrease. To account for this decreasing average rate, the conservation savings function in IWR-MAIN was used. Based on projected accounts, annual average per unit water use rates were calculated for the forecast years. These per unit water use rates were used to calculate percent differences of 2.8, 3.4, and 2.5 that were entered for years 2010, 2020, and 2030, respectively.

For the multifamily subsector, an average per unit water use rate of approximately 270 gallons/day/unit was calculated for the 2000 data by dividing the number of metered accounts into the metered water use. The number of metered multifamily housing units was estimated by multiplying the reported accounts by 19.5 housing units/account, which was estimated by Cal Water (California Water Service Company, 2002). Cal Water reports no unmetered multifamily accounts.

These monthly per unit water use rates were multiplied by the number of multifamily housing units from the 2000 demographic data to obtain the base year monthly water use totals shown in Table 3-2.

As will be discussed in Reasonableness of Results, Section 4.2, the per unit water use rates calculated for Chico are reasonable. However, the numbers of single-family and multifamily accounts reported by Cal Water to DWR shown in Table *A*-2 in Appendix *A* do not match well with the census counts of single-family and multifamily housing units discussed in Section 3.2.

For single-family accounts, the discrepancy is mostly due to the accounts that are outside of the incorporated boundaries of Chico, which are estimated based on area to be approximately 20 percent, and the accounts that are in Hamilton City, which are estimated to be approximately 2 percent of the total accounts reported by Cal Water. Another reason for the discrepancy is that some housing units may be classified as single-family units when they are actually multifamily, for example, when a house is converted to apartments.

For multifamily accounts, the discrepancy is mostly due to the fact that each account represents multiple units. Cal Water estimated an average of 19.5 units per account (California Water Service Company, 2002). Also, as discussed above, another reason may be the classification of housing units used by Cal Water.

The per unit water use rates may be slightly different if more detailed studies were conducted to determine more precise counts of accounts. The water use calculated for this analysis for Chico should be adequate for the purposes of this analysis.

The water use listed under the category “other” in Table *A*-2 in Appendix *A* was assumed to be for the large landscape subsector. Approximately 50 percent of these accounts were unmetered in year 2000. The water use for the unmetered large landscape accounts was assumed to have the same per unit water use rate as the metered accounts. The metered water deliveries were prorated by the number of unmetered accounts to estimate the total water deliveries.

3.1.3 Gridley Base Year Water Use

Table 3-3 shows the base year monthly water use as entered into the IWR-MAIN model for Gridley, which is served by the City of Gridley. The data in Table 3-3 is based directly on DWR PWSS. Table *A*-3 in Appendix *A* shows the DWR PWSS for year 2000 for Gridley.

Table 3-3
Base Year (2000) Water Use for Gridley in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	10.33	10.42	19.97	20.36	35.17	42.77	41.10	33.77	23.65	28.00	15.52	10.59
Multifamily	1.41	1.63	2.64	7.16	4.73	6.74	5.70	5.20	5.01	3.73	2.44	1.63
Commercial	6.51	4.80	7.53	8.25	13.70	13.83	14.72	11.68	8.99	10.13	7.19	4.60
Industrial	0.03	0.02	0.11	0.09	0.12	0.48	0.31	0.16	0.13	0.38	0.13	0.04
Lg. Landscape	0.01	0.01	0.06	0.58	0.18	0.15	0.15	0.12	0.06	0.11	0.02	0.02

While CDM made no adjustments to the DWR water use statistics, the demographic data for the commercial and industrial subsectors in Gridley required adjustments to reflect information gained in interviews, as described in Section 3.2.2. These adjustments to the demographic data affect the per unit water use rates for these subsectors.

3.1.4 Oroville Base Year Water Use

Table 3-4 shows the base year monthly water use as entered into the IWR-MAIN model for Oroville, which is served by three water purveyors: Cal Water Service of Oroville (Cal Water), Oroville Wyandotte Irrigation District (OWID), and Thermalito Irrigation District (TID). The data in Table 3-4 is based on DWR PWSS, information obtained from interviews with water purveyors, and other available information, as described below. Tables *A*-4, *A*-5, and *A*-6 in Appendix A show the DWR PWSS for year 2000 for Cal Water, OWID, and TID.

Table 3-4
Base Year (2000) Water Use Rates for Oroville in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	27.98	25.27	27.66	36.81	52.26	75.34	92.31	87.36	76.66	60.71	40.74	28.13
Multifamily	3.99	3.68	4.19	5.30	5.76	7.85	8.88	9.02	7.55	6.50	4.91	4.02
Commercial	19.73	20.94	18.31	25.64	31.65	41.14	47.39	50.25	49.63	39.79	30.41	19.61
Industrial	6.36	5.49	3.96	5.27	5.24	5.98	7.49	43.28	49.08	31.95	22.35	2.16
Lg. Landscape	0.00	0.00	0.00	0.00	0.14	0.26	0.26	0.28	0.19	0.11	0.06	0.00

Oroville's three water purveyors serve areas both inside and outside of the incorporated boundaries. The percentage of water use in the incorporated area was not available from the water purveyors; however, the number of metered accounts in the city versus outside was available for OWID and TID. According to both OWID (Barber 2003) and TID (Bird 2003), water use rates inside and outside of the incorporated area are similar. Therefore, for OWID and TID, water use in the incorporated area was prorated from the total water use for each water purveyor based on the number of accounts inside the incorporated area compared to the total number of accounts for each subsector.

The Cal Water service area is almost entirely in the town of Oroville (Alt 2003), although about 6 percent of the accounts are unmetered. This analysis assumes that the unmetered Cal Water accounts have similar water use rates as the metered accounts. CDM increased the water use for metered accounts for Cal Water proportionally according to the number of unmetered accounts to estimate the total water use in the Cal Water service area.

Equation 3.2 is an example calculation of base year water use in the incorporated area for the single-family subsector in Oroville. Similar calculations were made for all of the other subsectors. The total water use in the town of Oroville is the sum of the water use in the incorporated area for each water purveyor. The water use for Cal Water is almost entirely in the incorporated area. The water use for OWID and TID is proportional to the number of water use accounts in the incorporated area.

$$Q_{Jan,Oroville} = Q_{Jan,CalWater} + \left(\frac{A_{OWID,\ Incorporated}}{A_{OWID,\ Total}} \times Q_{Jan,OWID} \right) + \left(\frac{A_{TID,\ Incorporated}}{A_{TID,\ Total}} \times Q_{Jan,TID} \right) \qquad \text{[Eq. 3.2]}$$

where:

Q = Gallons of water used in the base year for the single-family subsector in January in a particular area

A = Number of single-family accounts in a particular study area in the base year

The water use under the category "other" in the DWR water statistics for Cal Water Service, Oroville, was assumed to be for public authorities. This water use was added to the commercial subsector.

3.1.5 Paradise Base Year Water Use

Table 3-5 shows the base year monthly water use as entered into the IWR-MAIN model for the Paradise Irrigation District (PID). The data in Table 3-5 is based on DWR PWSS and on information obtained from interviews with PID. Table *A*-7 in Appendix *A* shows the DWR PWSS for year 2000 for PID.

Table 3-5
Base Year (2000) Water Use for Paradise in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	58.53	52.56	46.29	63.90	96.45	114.37	193.50	196.79	212.02	168.72	146.92	77.04
Multifamily	5.37	4.82	4.24	5.86	8.85	10.49	17.79	18.05	19.44	15.47	13.47	7.07
Commercial	22.61	17.65	18.58	20.13	35.62	34.07	59.15	57.29	62.56	46.76	39.95	22.92
Industrial	1.19	0.93	0.98	1.06	1.87	1.79	3.11	3.02	3.29	2.46	2.10	1.21
Lg. Landscape	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The DWR PWSS data in Table *A*-7 list water use only for the single-family and commercial subsectors. CDM estimated the percentages of the year 2000 water use among the other subsectors based on information provided by PID.

PID (Auerbach 2003) provided total water use data for 2002 for all of the subsectors. In 2002, 91.6 percent of water use in the residential sector was in the single-family subsector and 8.4 percent was in the multifamily subsector. In the nonresidential sector, 99.9 percent was in the commercial subsector, while 0.1 percent was in the industrial subsector. However, this proportion between subsectors of the nonresidential sector yielded unreasonable per unit water use rates for the industrial subsector. Thus, CDM assumed 95 and 5 percent for the commercial and industrial subsectors, respectively, which yielded reasonable per unit water use rates for both subsectors. There was no reported water use in the large landscape subsector. These percentages were applied to the 2000 DWR PWSS data to obtain the base year water use for Paradise shown in Table 3-5.

3.1.6 Unincorporated Areas Base Year Water Use

Table 3-6 shows the assumed base year monthly water use as entered into the IWR-MAIN model for the unincorporated areas of Butte county, which are served by several urban water purveyors and by a significant number of private wells. The data in Table 3-6 is based on representative per unit water used rates and on information obtained from interviews.

Available demographic data does not correspond well with the areas served by Butte County water purveyors in the unincorporated areas. In addition, private well water use data across the county was not available; therefore, per unit water use rates for the unincorporated areas were not directly available. Instead, representative per unit water use rates were developed from Gridley and OWID PWSS and from information obtained from interviews with DWR; these per unit water use rates were applied to the unincorporated areas. Tables *A*-3 and *A*-5 in Appendix A show the DWR water system statistics for year 2000 for Gridley and OWID.

Table 3-6
Base Year (2000) Water Use for Unincorporated Butte County in Million Gallons

Subsector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Single-Family	231.28	173.96	248.38	371.71	732.30	744.81	980.43	796.10	823.62	663.72	416.52	213.60
Multifamily	54.24	62.91	102.05	276.48	182.54	259.98	219.89	200.86	193.29	143.90	94.22	62.81
Commercial	2.42	1.79	2.80	3.07	5.11	5.15	5.48	4.35	3.35	3.78	2.68	1.72
Industrial	0.24	0.17	0.77	0.62	0.82	3.38	2.14	1.13	0.94	2.68	0.89	0.29
Lg. Landscape	0.13	0.11	1.03	1.03	3.21	2.70	2.62	2.12	1.09	1.88	0.32	0.39

DWR conducted field reconnaissance surveys of land use in Butte County in 2001 (Hilare, 2003). These surveys found that some portions of the valley areas had land use similar to other areas for which information was available, as follows:

- Some areas were similar to Gridley; they were more urbanized with smaller lots, less landscaping, and more variety of land uses than other areas. These areas accounted for about 36 percent of the population in Butte County.

- Some areas were similar to OWID; these areas were more rural with larger lots, more landscaping, and less variety of land uses (primarily single-family residential) than other areas. These areas accounted for about 59 percent of the population in Butte County.

- The foothill and mountain areas had similar land use as Del Oro Water Company service areas of Paradise Pines and Magalia. These areas typically have lower per unit water use rates because they have less landscaping than other areas. These areas only account for about 5 percent of the population in Butte County.

A composite per unit water use rate for the single-family subsector was developed for the unincorporated areas based on a weighted average of the population distribution described above. That is, the per unit water use rate for the single-family subsector for Gridley was applied to approximately 36 percent of the unincorporated areas, and the per unit water use rate for the single-family subsector for OWID was applied to approximately 64 percent, including the 5 percent of population in the foothill and mountain regions. The water use of the 5 percent of population may be slightly overstated but has negligible effect on the overall per unit water use rate for the unincorporated areas. The following example equation was used to estimate the water use for the single-family subsector for January in the unincorporated areas.

$$Q_{Jan,Unincorp} = N_{Unincorp} \left(\frac{Q_{Jan,Gridley}}{A_{Gridley}} \times 0.36 + \frac{Q_{Jan,OWID}}{A_{OWID}} \times 0.64 \right) \quad [3.3]$$

where:

Q = Gallons of water used for the single-family subsector in January of the base year

A = Number of single-family accounts in the base year

N = Number of single-family housing units in the base year

For all other subsectors in the unincorporated areas, the per unit water use rates of Gridley for all of the other subsectors were applied. The water use in the unincorporated areas for a particular subsector was assumed to be proportional to the number of counting units in the unincorporated area. The following equation is an example of how the water use for the commercial subsector was estimated for the unincorporated areas.

$$Q_{Jan,Commercial,Unincorp} = N_{Commercial,Unicorp} \times \frac{Q_{Jan,Commercial,Gridley}}{N_{Commercial,Gridley}} \quad [3.4]$$

where:

Q = Gallons of water used for the commercial subsector in January of the base year

N = Number of commercial jobs in the base year

3.2 Demographic Projections

The forecast model uses counting units and explanatory variables derived from demographic projection data. All demographic data except for housing density were prepared by the Center for Economic Development (CED) of California State University, Chico. The CED based its analysis primarily on U.S. Census data. Based on interviews with city and county planners, CDM made adjustments to the data provided by the CED, as described in subsections 3.2.1 - 3.2.6 below. CDM obtained housing density information through interviews with city and county planners.

The CED provided demographic data for the incorporated areas and for the county as a whole. Using this data, CDM made estimates for the unincorporated areas of the county. Tables 3-7 through 3-12 summarize the demographic data for each study area.

Table 3-7
Demographic Projections for Biggs

Median Projection Demographic Data	Year				2000-2030 Total % Change	2000-2030 Ave. % Change per Year
	2000	2010	2020	2030		
Single-Family Housing Units	534	608	695	795	49	1.3
Multifamily Housing Units[1]	80	80	77	71	-11	-0.4
Industrial Jobs	333	315	295	275	-17	-0.6
Commercial Jobs	239	187	144	112	-53	-2.5
Population	1,799	1,958	2,124	2,291	27	0.8
Median Income (Year-2000 dollars)	$33,250	$38,680	$44,997	$52,345	57	1.5
Persons per household, Single-Family	3.01	2.86	2.71	2.58	-14	-0.5
Persons per household, Multifamily	2.55	2.55	2.55	2.55	0	0.0
Housing Density Single-Family (units/acre)	2	2	2	2	0	0.0
Housing Density Multifamily (units/acre)	8	8	8	8	0	0.0

[1]Includes housing units for the category *other*.

Table 3-8
Demographic Projections for Chico

Median Projection Demographic Data	Year				2000-2030 Total % Change	2000-2030 Ave. % Change per Year
	2000	2010	2020	2030		
Single-Family Housing Units	12,802	17,029	21,780	27,120	112	2.5
Multifamily Housing Units[1]	11,550	13,856	16,448	19,362	68	1.7
Industrial Jobs	7,794	7,384	6,898	6,444	-17	-0.6
Commercial Jobs	39,654	49,273	60,366	73,957	87	2.1
Population	59,444	74,956	92,871	114,125	92	2.2
Median Income (Year-2000 dollars)	$29,359	$34,424	$40,362	$47,325	61	1.6
Persons per household, Single-Family	2.54	2.30	2.07	1.87	-26	-1.0
Persons per household, Multifamily	2.08	2.38	2.73	3.12	50	1.4
Housing Density Single-Family (units/acre)	4	5.1	5.1	5.1	28	0.8
Housing Density Multifamily (units/acre)	16	20.4	20.4	20.4	28	0.8

[1]Includes housing units for the category other.

Table 3-9
Demographic Projections for Gridley

Median Projection Demographic Data	Year				2000-2030 Total % Change	2000-2030 Ave. % Change per Year
	2000	2010	2020	2030		
Single-Family Housing Units	1,634	1,768	1,922	2,097	28	0.8
Multifamily Housing Units[1]	352	417	486	561	59	1.6
Industrial Jobs	856	811	758	708	-17	-0.6
Commercial Jobs	1,884	1,785	1,667	1,558	-17	-0.6
Population	5,450	6,092	7,001	8,097	49	1.3
Median Income (Year-2000 dollars)	$24,368	$24,947	$25,541	$26,148	7	0.2
Persons per household, Single-Family	2.84	2.99	3.16	3.33	17	0.5
Persons per household, Multifamily	2.01	2.41	2.89	3.47	44	1.4
Housing Density Single-Family (units/acre)	4	4	4	4	0	0.0
Housing Density Multifamily (units/acre)	15	15	15	15	0	0.0

[1]Includes housing units for the category other.

Table 3-10
Demographic Projections for Oroville

Median Projection Demographic Data	Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year
Single-Family Housing Units	3,041	4,736	6,640	8,782	189	3.6
Multifamily Housing Units[1]	2,428	4,000	5,767	7,752	219	3.9
Industrial Jobs	3,133	2,968	2,773	2,590	-17	-0.6
Commercial Jobs	11,880	13,380	14,858	16,499	39	1.1
Population	12,969	19,401	26,021	32,868	153	3.1
Median Income (Year-2000 dollars)	$21,911	$21,933	$21,954	$21,976	0	0.0
Persons per household, Single-Family	2.52	2.41	2.31	2.21	-12	-0.4
Persons per household, Multifamily	1.91	1.78	1.66	1.54	-19	-0.7
Housing Density Single-Family (units/acre)	6	6	6	6	0	0.0
Housing Density Multifamily (units/acre)	20	20	20	20	0	0.0

[1]Includes housing units for the category other.

Table 3-11
Demographic Projections for Paradise

Median Projection Demographic Data	Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year
Single-Family Housing Units	8,834	9,628	10,525	11,535	31	0.9
Multifamily Housing Units[1]	3,485	3,464	3,437	3,403	-2	-0.1
Industrial Jobs	1,025	971	907	847	-17	-0.6
Commercial Jobs	6,433	6,830	7,150	7,484	16	0.5
Population	26,451	26,658	27,567	28,554	8	0.3
Median Income (Year-2000 dollars)	$31,863	$33,570	$35,369	$37,265	17	0.5
Persons per household, Single-Family	2.27	2.15	2.03	1.92	-15	-0.6
Persons per household, Multifamily	1.53	1.60	1.66	1.73	13	0.4
Housing Density Single-Family (units/acre)	3	3.06	3.17	3.27	9	0.3
Housing Density Multifamily (units/acre)	10	10	10.02	10.03	0.3	0.0

[1]Includes housing units for the category other.

Table 3-12
Demographic Projections for Unincorporated Areas of Butte County

Median Projection Demographic Data	Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year
Single-Family Housing Units	27,196	28,894	30,793	32,920	21	0.6
Multifamily Housing Units[1]	13,587	12,647	12,479	11,050	-19	-0.7
Industrial Jobs	805	764	712	666	-17	-0.6
Commercial Jobs	978	1,550	1,865	1,817	86	2.1
Population	97,058	91,598	92,165	88,757	-9	-0.3
Median Income (Year-2000 dollars)	$31,924	$34,260	$36,766	$39,456	24	0.7
Persons per household, Single-Family	2.49	2.38	2.27	2.17	-13	-0.5
Persons per household, Multifamily	2.02	2.03	2.03	2.04	1	0.0
Housing Density Single-Family (units/acre)	0.2	0.2	0.2	0.2	0	0.0
Housing Density Multifamily (units/acre)	15	15	15	15	0	0.0

[1]Includes housing units for the category other.

3.2.1 Housing Projections

The CED growth projections are based on the housing growth between 1990 and 2000. The CED assumed that future new single-family, multifamily, and other units would have the same distribution that they did between 1990 and 2000. Some adjustments to the distribution of growth in the cities were made by the CED to avoid unrealistically substantial demolition of multiple family or other units. The CED projections for housing may be summarized as follows:

- Biggs - a 49 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to decrease by 11 percent. The CED attributed part of these large increases in housing units to people that work in Chico moving to Biggs.

- Chico - a 112 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to increase by 68 percent. The CED attributed part of these large increases in housing units to annexation of already developed areas adjacent to the incorporated boundaries of Chico.

- Gridley - a 28 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to increase by 59 percent. The CED attributed part of these large increases in housing units to people that work in Chico moving to Gridley.

- Oroville - a 189 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to increase by 232 percent. The CED attributed part of these large increases in housing units to annexation of already developed areas adjacent to the incorporated boundaries of Oroville.

- Paradise - a 31 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to increase by 3 percent. The CED did not project much growth for Paradise because it is nearly built out to its general plan.

Housing units in the category "other" include mobile homes, recreational vehicles, vans, and other, as reported in the census. For this study, CDM added the units in this category to the multifamily residential subsector.

For the unincorporated areas of the county, CDM estimated the housing data by subtracting the sum of the data for the incorporated areas from the data for the county as a whole. The projections are for a 21 percent increase in single-family housing units from 2000 to 2030. During the same time, the multifamily units are projected to decrease by 19 percent.

3.2.2 Employment Projections

As with housing growth, the CED assumed that future job growth in Butte County would be at least as strong as it was between 1990 and 2000. The CED assumed, however, that the distribution of growth between industrial and commercial jobs would change.

Industrial jobs include jobs in agriculture, forestry, fishing, mining, construction, manufacturing, wholesale trade, and transportation. Commercial jobs include jobs in retail trade, finance, insurance, real estate, business and personal services, government, and other unclassified establishments. The CED assumed that the decline in industrial jobs seen between 1990 and 2000 would soften in the future, but would decline nonetheless. The CED made adjustments to the distribution of growth in the cities to avoid unrealistically substantial declines in industrial jobs.

CDM adjusted the commercial and industrial job counts for Gridley based on interviews with city staff (Wilke 2003). The industrial job count for the year 2000 from the census data was reduced, and the difference was shifted to the commercial job count. The commercial and industrial job data for the projected years were estimated by multiplying the adjusted year 2000 data by the same percentage increases originally used by the CED.

The employment data for the unincorporated areas of the county were calculated by CDM by subtracting the sum of the data for the incorporated areas from the data for the county as a whole.

The CED projected several of the study areas, such as Biggs, Gridley, and Oroville, to have substantial growth in population and housing and corresponding decline or not as substantial growth in employment. The CED attributed these reverse trends to the fact that most new jobs are Chico and housing supply in Chico is not keeping pace with demand. Therefore, many employees are living in other cities and commuting to Chico. The CED did not project similar housing growth in Paradise because it is nearly built out.

3.2.3 Population

The CED calculated population as the sum of persons per household in single family, multiple family, and other units multiplied by the number of housing units in each category. Housing units by type and persons per household by type were projected separately.

CDM calculated the population data for the unincorporated areas of the county by subtracting the sum of the data for the incorporated areas from the data for the county as a whole.

The CED projected some of the study areas, such as Chico, Gridley, and Oroville, to have very high rates of growth. The CED attributed this growth to high rates of growth in the incorporated areas and also to annexation of already developed areas adjacent to the incorporated boundaries.

3.2.4 Median Income

Median income for this study is the median income of all households. The CED adjusted these figures for inflation and reported them in year 2000 equivalent dollars. In Butte County as a whole, and in Gridley, where real income in 2000 was less than in 1990, the CED assumed that the income trend would reverse by 2010 and begin a slow increase. For all other communities, the CED assumed that income growth would continue at a rate equal to or greater than that between 1990 and 2000.

For this study, CDM assumed that the median income projection for the unincorporated areas of the county to be the same as the one made by the CED for the county as a whole.

The CED projected a large increase in median income for both Biggs and Chico. Chico is the center for new job creation in the county and therefore will much income growth. The CED attributed this large increase for Biggs to people that work in Chico and live in Biggs because housing supply is not keeping pace with housing demand in Chico.

3.2.5 Persons per Household

In Butte County and most of its communities, the number of persons per household declined between 1990 and 2000. The CED assumed this trend would continue in the future. In Gridley, where persons per household is increasing, the CED also assumed that this trend would continue, because increased farm worker housing built within the city limits would support greater numbers of people per unit.

For this study, CDM assumed that the persons per household values for the unincorporated areas of the county would be similar to the persons per household values of the county as a whole.

3.2.6 Housing Density

Housing density is an estimate of the average number of housing units per acre of developed area, for areas with a residential land use designation. It does not include areas of other land use designations, such as commercial or open space, and it does not include undeveloped residential areas. CDM obtained housing density information through interviews with city and county planners.

For all areas except Chico, housing densities were expected to stay relatively constant for the projection period. The housing densities for Chico, for both single family and multifamily, were expected to increase in the next 10 years, because of a change in land use designations in the city’s general plan (Hayes 2003).

3.3 Weather Data

This analysis uses weather data, including average daily maximum temperature, total precipitation, and cooling degree-days, as explanatory variables. Data for these variables were obtained from the Western Regional Climate Center Internet site (Western Regional Climate Center 2003). Data from three weather gauge stations were used to represent the weather of the study areas. Table 3-13 identifies each study area and the corresponding weather gauging station used as a source of input data. Tables 3-14 through 3-16 contain weather data used for model input from the three gauge stations.

Table 3-13
Weather Gauge Station Data Used for Model Study Areas

Study Area	Weather Gauge Station
Biggs	Oroville, CA
Chico	Chico Experimentation Station, Chico, CA
Gridley	Oroville, CA
Oroville	Oroville, CA
Paradise	Paradise, CA
Unincorporated Areas	Paradise, CA

Year 2000 weather data was used as input for the base year. Normal values (1971-2000) were used for all projection years.

Cooling degree days are the total number of degrees that the daily average temperature exceeds 65°. The total cooling degree days for the month is the sum of the cooling degrees for all days in the month. More cooling degree days requires more water use for equipment such as cooling towers, which are common in commercial buildings.

Year 2000 cooling degree data for the Chico and Paradise gauge stations were generally available; however, some of the data were missing for a few days in a few of the months. The cooling degree days for these months were adjusted to compensate for the missing days. The cooling degree days for missing days was estimated by calculating an average cooling degrees per day using the available data for a month. This average cooling degrees per day was multiplied by the number of missing days and added to the original monthly total.

Year 2000 cooling degree day data for the Oroville gauge station had many missing days of data for many of the months. Therefore, the cooling degree days for this gauge station were estimated from the year 2000 monthly average temperature data. The monthly cooling degree days was calculated as the monthly average temperature minus 65 °F multiplied by the number days in the month. Negative results were set to zero.

Table 3-14
Chico Experimentation Station, Chico, CA, Weather Gauge Data

Weather Variable	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Maximum Temperature (°F)	53.7	60.0	64.9	71.9	80.1	87.8	93.0	92.2	88.4	78.7	63.0	54.4
Total Precipitation (inches)	5.17	4.5	4.32	1.59	0.91	0.47	0.05	0.16	0.59	1.34	3.5	3.63
Cooling Degree Days (°F)	0	0	2	24	114	229	367	323	207	67	1	0
2000 Monthly Average Maximum Temperature (°F)	56.7	58.9	66.9	76.5	80.3	92.9	91.0	93.0	88.9	76.4	59.2	58.0
2000 Monthly Total Precipitation (inches)	5.48	8.42	3.39	2.37	0.96	0.39	0.00	0.00	0.27	2.91	2.26	0.25
2000 Monthly Total Cooling Degree Days (°F)	0	0	0	25	125	351	296	338	200	66	0	0

Table 3-15
Oroville, CA, Weather Gauge Data

Weather Variable	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Maximum Temperature (°F)	54.8	60.9	65.3	72.1	80.7	89.6	96.5	94.9	89.0	79.0	64.9	55.0
Total Precipitation (inches)	5.76	4.90	4.24	2.08	0.97	0.39	0.05	0.16	0.43	1.65	3.70	4.33
Cooling Degree Days (°F)	0	0	1	22	117	282	447	388	231	64	1	0
2000 Monthly Average Maximum Temperature (°F)	57.1	58.7	66.9	76.1	83.7	95.1	94.3	94.9	91.4	75.5	60.6	58.2
2000 Monthly Total Precipitation (inches)	5.46	8.67	3.87	1.83	0.85	0.75	0.00	0.00	0.00	0.50	0.38	1.23
2000 Monthly Total Cooling Degree Days (°F)	0	0	0	8	246	370	371	403	225	22	0	0

Table 3-16
Paradise, CA, Weather Gauge Data

Weather Variable	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Maximum Temperature (°F)	53.7	56.5	59.7	66	74.7	84.2	91.6	90.5	85.0	74.2	60.4	54.0
Total Precipitation (inches)	11.12	9.04	8.27	3.91	1.77	0.70	0.09	0.28	0.94	3.13	7.37	8.33
Cooling Degree Days (°F)	0	0	1	16	78	220	396	364	233	71	2	0
2000 Monthly Average Maximum Temperature (°F)	52.5	53.3	61.1	70.1	75.0	88.9	88.0	91.1	82.8	70.2	55.1	57.7
2000 Monthly Total Precipitation (inches)	11.44	23.14	6.67	2.84	2.00	0.42	0.00	0.00	0.31	7.43	2.24	2.52
2000 Monthly Total Cooling Degree Days (°F)	0	0	0	29	122	349	331	410	237	57	0	0

Note: Mean maximum temperature, total precipitation and cooling degree days listed in Tables 3-14 – 3-16 are 1971 – 2000 normal monthly values.

3.4 Marginal Price

Marginal price, which is the price of water and sewer service per quantity of water in excess of a base volume at a flat cost, is an explanatory variable in the model. Marginal price data was obtained from interviews with water purveyors. Table 3-17 is a list of marginal prices used for the residential sector. Table 3-18 is a list of marginal prices used for the nonresidential sector.

Table 3-17
Marginal Price for Residential Water by Study Area in Dollars per 1000 Gallons (Year 2000 Dollars)

Study Area	2000	2010	2020	2030
Biggs	$1.00	$1.00	$1.00	$1.00
Chico	$0.61	$0.73	$0.73	$0.73
Gridley	$0.68	$0.68	$0.68	$0.68
Oroville	$1.30	$1.90	$1.90	$1.90
Paradise	$0.64	$0.64	$0.64	$0.64
Unincorporated Areas	$1.00	$1.00	$1.00	$1.00

Table 3-18
Marginal Price for Nonresidential Water by Study Area in Dollars per 1000 Gallons (Year 2000 Dollars)

Study Area	2000	2010	2020	2030
Biggs	$1.00	$1.00	$1.00	$1.00
Chico	$0.61	$0.73	$0.73	$0.73
Gridley	$0.68	$0.68	$0.68	$0.68
Oroville	$1.30	$1.90	$1.90	$1.90
Paradise	$0.74	$0.74	$0.74	$0.74
Unincorporated Areas	$1.00	$1.00	$1.00	$1.00

Many water purveyors have a water rate structure that is tiered according to the level of usage. That is, the price per quantity of water may change depending on the amount of water used. For study areas with a tiered price structure, the marginal price corresponding to the average water use quantity was used in the model. For areas with flat rates (Biggs) or negligible marginal price, such as those areas served by private wells (unincorporated areas), a marginal price of one dollar was entered for all forecast years. This value was entered for convenience and, because the marginal price is held constant, it has no effect on the forecast. The marginal prices used for Oroville were the average of the marginal prices, weighted by number of accounts in the incorporated area, of the three water purveyors that serves this area.

The marginal prices are expressed here in constant year 2000 dollars. Increases in marginal price between forecast years were made based on information from interviews with the water purveyor staff. Typically, increases were made to reflect specific plans to raise rates for capital improvements. Both Chico and Oroville anticipated increases in the marginal price of water. No increases were made for inflation.

3.5 Elasticities

Elasticity is a measure of the sensitivity of the per unit water use rate to the change in the explanatory variable; it indicates the percent change in per unit water use given a percent change in the variable value. Elasticities for the explanatory variables were selected from the IWR-MAIN user's manual (Planning and Management Consultants, Ltd. 1999) based on familiarity with the demographics of the study areas. No calibration of historical data was conducted in the development of the elasticities. Table 3-19 is a list of the elasticities used in the model.

Table 3-19
Model Elasticities

Explanatory Variable	Elasticity	
	Residential	
	Single Family	Multifamily
Income	0.4	0.4
Housing Density	-0.4	-0.4
Persons/Household	0.4	0.5
Marginal Price	-0.1	-0.05
Maximum Temperature	0.97	0.45
Precipitation	-0.11	-0.03
	Nonresidential	
Maximum Temperature	0.45	
Precipitation	-0.03	
Marginal Price	-0.1	
Cooling Degree Days	0.12	

3.6 Unmetered/Unaccounted

The unmetered/unaccounted water category in IWR-MAIN accounts for water losses in the water purveyors' conveyance systems, as well as unmetered use, system flushing, and fire fighting. The percent loss represents the difference between water production and metered consumption. Table 3-20 is a list of percent water losses used in the model for each study area.

Except for Biggs and the unincorporated areas, the percent losses for the base year were calculated from the DWR public water system statistic data. The percent water loss was calculated based on the difference between the amount of water entering the system and the amount of water deliveries to the water users on that system. For areas with metered accounts, the water deliveries were taken directly from the PWSS. For areas with some unmetered accounts, the total water deliveries were estimated as discussed in Section 3.1. An estimate of the percent loss for Biggs was obtained from an interview with the city consultant (Swartz 2003). It was assumed that that the unincorporated areas had no significant losses. This assumption seems reasonable because many of these areas are served by private wells. That is, the water supply is developed on the property of the water user.

The percent losses for the forecasted years were the same as for the base year, except for Paradise. For Paradise, decreases in percent loss were used based on actions described in Paradise Irrigation District's Urban Water Management Plan (PID 2000).

The district has a water main replacement program that will be implemented during the next few decades.

The water losses listed in Table 3-20 range from 0 to 23 percent. These values are typical for the water supply conveyance industry.

Table 3-20
Percent Water Loss by Study Area

Study Area	2000	2010	2020	2030
Biggs	23%	23%	23%	23%
Chico	10%	10%	10%	10%
Gridley	8%	8%	8%	8%
Oroville	22%	22%	22%	22%
Paradise	17%	12%	8%	8%
Unincorporated Areas	0%	0%	0%	0%

Section 4 – Findings

4.1 Summary of Results

Forecasts of the water demand for Butte County were generated using the IWR-MAIN Water Demand Management Suite software. The Forecast Manager was used to execute the model. Figure 4-1 shows the total projected water demand for each study area and the county. Tables 4-1 through 4-6 show the projected water demands for the study areas, and Table 4-7 shows the total projected water demand for the entire county. Appendix *B* contains detailed IWR-MAIN water demand forecast output for each study area. The results for each study area are discussed below.

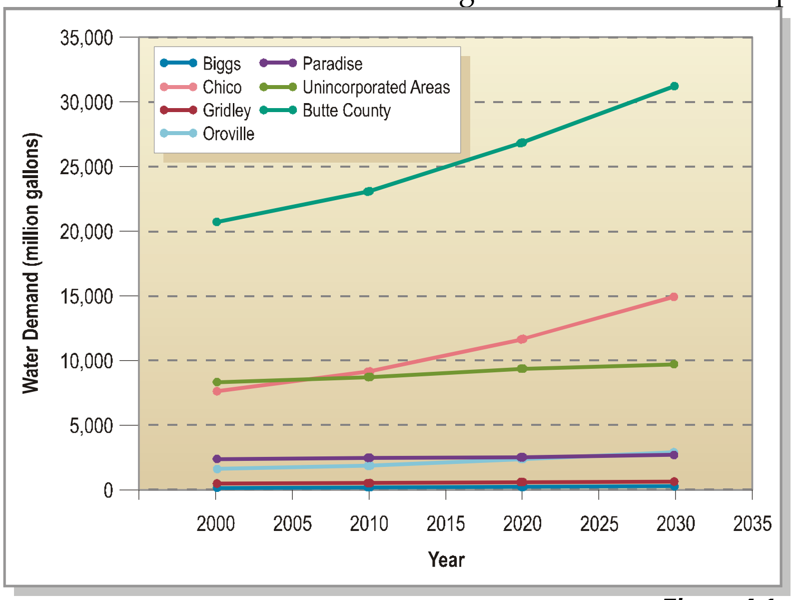

Figure 4-1
Projected Total Water Demand for Butte County

4.1.1 Water Demand Projections for Biggs

The demand for Biggs is projected to grow from 186.4 million gallons (572.1 acre-feet) in 2000 to 269.2 million gallons (826.2 acre-feet) in 2030, an increase of 44 percent. The growth in water demand is primarily due to a projected 49 percent growth in single-family housing units. The increase in single-family water use is also due to economic factors. The projected 57 percent increase in median income is the main factor that increases the single-family per unit water use rate by 12 percent between 2000 and 2030.

Table 4-1
Projected Water Demand for Biggs

Subsector	Water Use in Million Gallons – Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year (1)
Single-Family	109.04	128.65	152.40	181.11	66	1.7
Multifamily	12.44	13.20	13.46	13.15	6	0.2
Commercial	14.87	11.64	8.96	6.97	-53	-2.5
Industrial	6.04	5.72	5.35	4.99	-17	-0.6
Large Landscape	1.09	1.08	1.08	1.08	-1	0.0
Unmetered/Unaccounted	42.86	47.88	54.14	61.92	44	1.2
Total	186.35	208.16	235.39	269.21	44	1.2

1. Based on compound interest function.

4.1.2 Water Demand Projections for Chico

The demand for Chico is projected to grow from 7,616.1 million gallons (23,374.5 acre-feet) in 2000 to 14,933.7 million gallons (45,832.8 acre-feet) in 2030, an increase of 96 percent. The growth in water demand is primarily due to projected increases in single-family, multifamily, and commercial water use. This growth in residential water demand is due to projected new housing growth and annexation of already developed land adjacent to the incorporated boundaries. The increase in multifamily water use is also due to economic factors. The multifamily per unit water use rate is projected to increase by 39 percent between 2000 and 2030 primarily due to the projected 61 percent increase in median income and the 50 percent increase in persons per household. Increase in commercial water use is primarily due to the projected 87 percent increase in commercial jobs between 2000 and 2030.

Table 4-2
Projected Water Use for Chico

Subsector	Water Use in Million Gallons – Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
Single-Family	3,397.69	3,980.48	5,176.60	6,678.63	97	2.3
Multifamily	1,136.23	1,457.27	1,977.15	2,653.92	134	2.9
Commercial	2,164.87	2,628.70	3,220.51	3,945.59	82	2.0
Industrial	124.06	115.44	107.84	100.75	-19	-0.7
Large Landscape	31.67	40.45	50.15	61.48	94	2.2
Unmetered/Unaccounted	761.61	913.59	1,170.25	1,493.37	96	2.3
Total	7,616.14	9,135.93	11,702.51	14,933.74	96	2.3

1. Based on compound interest function.

4.1.3 Water Demand Projections for Gridley

The demand for Gridley is projected to grow from 494.4 million gallons (1,517.4 acre-feet) in 2000 to 662.0 million gallons (2,031.7 acre-feet) in 2030, an increase of 34 percent. The growth in water demand is primarily due to projected increases in single-family and multifamily housing units. The increase in single-family and multifamily water use is also due to economic factors. The projected increases in persons per household are the main factors that increase the multifamily per unit water rate for both subsectors.

Table 4-3
Projected Water Use for Gridley

Subsector	Water Use in Million Gallons – Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
Single-Family	291.95	323.36	365.07	406.75	39	1.1
Multifamily	48.02	62.86	81.50	103.08	115	2.6
Commercial	111.93	106.34	101.01	95.98	-14	-0.5
Industrial	2.00	1.81	1.81	1.72	-14	-0.5
Large Landscape	0.93	1.11	1.29	1.48	58	1.5
Unmetered/Unaccounted	39.55	43.09	47.89	52.96	34	1.0
Total	494.38	538.57	598.57	661.98	34	1.0

1. Based on compound interest function.

4.1.4 Water Demand Projections for Oroville

The demand for Oroville is projected to grow from 1,650.4 million gallons (5,065.2 acre-feet) in 2000 to 2,927.8 million gallons (8,985.7 acre-feet) in 2030, an increase of 77 percent. The growth in water demand is primarily due to projected increases in single-family and multifamily housing units. This growth in housing is due to projected new housing growth and annexation of already developed land adjacent to the incorporated boundaries. The per unit water use rate for both subsectors is projected to decrease slightly 2000 to 2030 due to projected decreases in persons per household.

Table 4-4
Projected Water Use for Oroville

Subsector	Water Use in Million Gallons Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year[(1)]
Single-Family	631.23	784.62	1,081.57	1,405.38	123	2.7
Multifamily	71.65	109.54	152.51	197.45	176	3.4
Commercial	394.49	427.75	475.01	527.47	34	1.0
Industrial	188.61	172.02	160.72	150.11	-20	-0.8
Large Landscape	1.30	1.89	2.58	3.28	152	3.1
Unmetered/Unaccounted	363.08	421.90	528.11	644.12	77	1.9
Total	1,650.36	1,917.72	2,400.50	2,927.81	77	1.9

1. Based on compound interest function.

4.1.5 Water Demand Projections for Paradise

The demand for Paradise is projected to grow from 2,431.3 million gallons (7,461.9 acre-feet) in 2000 to 2,701.2 million gallons (8290.2 acre-feet) in 2030, an increase of 11 percent. The growth in water demand is primarily due to projected increases in single-family housing units. This projected growth in housing is less than in other study areas because Paradise is nearly built out to its general plan. The per unit water use rate for all subsectors is projected to stay relatively constant from 2000 to 2030.

Table 4-5
Projected Water Use for Paradise

Subsector	Water Use in Million Gallons Year 2000	2010	2020	2030	2000-2030 Total % Change	2000-2030 Ave. % Change per Year[(1)]
Single-Family	1,426.89	1,572.39	1,675.60	1,813.62	27	0.8
Multifamily	130.87	137.30	140.26	143.84	10	0.3
Commercial	437.20	464.18	485.93	508.63	16	0.5
Industrial	23.01	21.80	20.36	19.01	-17	-0.6
Large Landscape	0.00	0.00	0.00	0.00	0	0.0
Unmetered/Unaccounted	413.32	299.41	201.93	216.10	-48	-2.1
Total	2,431.29	2,495.07	2,524.08	2,701.20	11	0.4

1. Based on compound interest function.

4.1.6 Water Demand Projections for the Unincorporated Areas of the County

The demand for the unincorporated areas of the county is projected to grow from 8,322.3 million gallons (25,541.8 acre-feet) in 2000 to 9,736.4 million gallons (29,881.8 acre-feet) in 2030, an increase of 17 percent. The growth in water demand is primarily due to projected increases in single-family and multifamily housing units. Housing units in the unincorporated areas of the county are projected to increase despite annexation of already developed land adjacent into incorporated areas. Even though the housing is projected to increase, the population in the unincorporated areas is projected to decrease because of corresponding decrease in persons per household for single-family residences. The per unit water use rate for all subsectors is projected to stay relatively constant from 2000 to 2030.

Table 4-6
Projected Water Use for the Unincorporated Areas

Subsector	Water Use in Million Gallons				2000-2030 Total % Change	2000-2030 Ave. % Change per Year[1]
	Year					
	2000	2010	2020	2030		
Single-Family	6,396.78	6,892.63	7,462.24	7,994.69	25	0.7
Multifamily	1,853.16	1,770.76	1,814.57	1,638.48	-12	-0.4
Commercial	41.70	65.13	78.37	76.35	83	2.0
Industrial	14.08	13.36	12.45	11.65	-17	-0.6
Large Landscape	16.62	15.71	15.71	15.20	-9	-0.3
Unmetered/Unaccounted	0.00	0.00	0.00	0.00	0	0.0
Total	8,322.34	8,757.59	9,383.35	9,736.37	17	0.5

1. Based on compound interest function.

4.1.7 Water Demand Projections for the County as a Whole

The water demand for the entire county is the summation of the water demand for all of the study areas. The demand for the entire county is projected to grow from 20,700.9 million gallons (63,532.8 acre-feet) in 2000 to 31,230.3 million gallons (95,848.4 acre-feet)in 2030, an increase of 51 percent. As illustrated by Figure 4-2, the growth in water demand is primarily due to projected increases in single-family, multifamily, and commercial water use in Chico. The growth in residential water demand is due to projected new housing growth and annexation of already developed land adjacent to the incorporated boundaries. In addition, the multifamily per unit water use rate is projected to

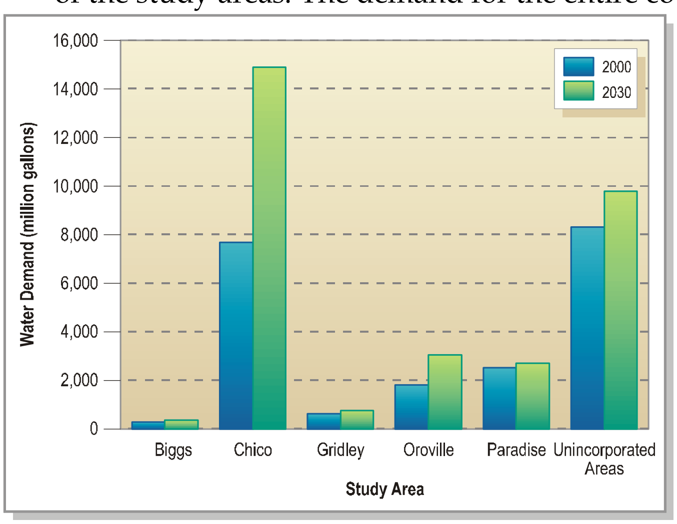

Figure 4-2
Projected Total Water Demand for Butte County for 2000 and 2030

increase substantially between 2000 and 2030, primarily due to economic factors. Increase in commercial water use in Chico is primarily due to the projected increase in commercial jobs between 2000 and 2030.

Table 4-7
Projected Water Use for Butte County

Subsector	Water Use in Million Gallons				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
	Year					
	2000	2010	2020	2030		
Single-Family	12,253.58	13,682.13	15,913.49	18,480.18	51	1.4
Multifamily	3,252.37	3,550.92	4,179.44	4,749.92	46	1.3
Commercial	3,165.06	3,703.75	4,369.79	5,160.99	63	1.6
Industrial	357.80	330.15	308.54	288.24	-19	-0.7
Large Landscape	51.62	60.24	70.82	82.52	60	1.6
Unmetered/Unaccounted	1,620.42	1,725.86	2,002.31	2,468.47	52	1.4
Total	20,700.87	23,053.06	26,844.40	31,230.31	51	1.4

1. Based on compound interest function.

4.2 Reasonableness of Results

The forecasts were compared to other similar information to determine the reasonableness of the results. The per unit water use rates computed by the model over the forecast duration were compared to ranges of typical values for the water supply industry. The water demand forecast was compared to three other independently conducted studies. These comparisons are detailed below.

4.2.1 Comparison of Per Unit Water Use Rates with Typical Values

Table 4-8 shows ranges of typical values of per unit water use rates for the various subsectors. Tables 4-9 through 4-14 show the per unit water use rates that were computed by the model for the various study areas.

Most of the per unit water use rates calculated by the model fall within or near the typical ranges expected over the duration of the forecast. The residential sector generally has per unit water use rates on the high end of the ranges. These high rates may be an indication of a potential for reductions in water use through conservation programs.

The per unit water use rates for the multifamily subsector in Paradise and Oroville, in contrast, are approximately 50 to 60 percent lower than the lowest value of the typical range for this subsector. Despite this difference, these rates are not unrealistic.

The per unit water use rates for the single-family subsector Chico are 35 to 45 percent more than the highest value of the typical range. The per unit water use rates for Chico account for unmetered water use, which can often be substantially higher than metered water use. These rates are not unrealistic.

Although these per unit use rates for Paradise and Chico are out of the typical ranges, they should be adequate for the purposes of this analysis. More detailed studies would be required to verify these per unit water use rates, if deemed necessary.

Table 4-8
Typical Per Unit Urban Water Use Rates

Subsector	Counting Unit	Water Use in Gallons per Day per Counting Unit
Single-Family	Housing units	380-500
Multifamily	Housing units	200-350
Commercial	Employee counts	120-150
Industrial	Employee counts	50-120

Table 4-9
Projected Average Daily Per Unit Water Use for Biggs

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	559.45	579.70	600.76	624.13	12	0.4
Multifamily	Housing units	425.96	452.16	478.77	507.28	19	0.6
Commercial	Employee counts	170.50	170.50	170.50	170.50	0	0.0
Industrial	Employee counts	49.72	49.72	49.72	49.72	0	0.0
Lg. Landscape	Total Population in 1000's	1,497.26	1,479.78	1,479.78	1,479.78	-1	0.0

1. Based on compound interest function.

Table 4-10
Projected Average Daily Per Unit Water Use for Chico

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	727.13	640.40	651.17	674.69	-7	-0.2
Multifamily	Housing units	269.52	288.14	329.33	375.53	39	1.1
Commercial	Employee counts	149.57	146.16	146.16	146.16	-2	-0.1
Industrial	Employee counts	43.61	42.83	42.83	42.83	-2	-0.1
Lg. Landscape	Total Population in 1000's	1,470.77	1,477.50	1,477.50	1,477.50	0	0.0

1. Based on compound interest function.

Table 4-11
Projected Average Daily Per Unit Water Use for Gridley

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	489.51	501.09	520.40	531.42	9	0.3
Multifamily	Housing units	373.75	413.02	459.43	503.43	35	1.0
Commercial	Employee counts	116.82	116.82	116.82	116.82	0	0.0
Industrial	Employee counts	47.65	47.65	47.65	47.65	0	0.0
Lg. Landscape	Total Population in 1000's	511.45	506.08	506.08	506.08	-1	0.0

1. Based on compound interest function.

Table 4-12
Projected Average Daily Per Unit Water Use for Oroville

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	568.69	453.90	446.27	438.44	-23	-0.9
Multifamily	Housing units	79.54	75.02	72.45	69.78	-12	-0.4
Commercial	Employee counts	90.98	87.59	87.59	87.59	-4	-0.1
Industrial	Employee counts	164.93	158.79	158.79	158.79	-4	-0.1
Lg. Landscape	Total Population in 1000's	273.97	272.27	272.27	272.27	-1	0.0

1. Based on compound interest function.

Table 4-13
Projected Average Daily Per Unit Water Use for Paradise

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	442.53	447.44	436.17	430.76	-3	-0.1
Multifamily	Housing units	102.88	108.59	111.81	115.81	13	0.4
Commercial	Employee counts	186.20	186.20	186.20	186.20	0	0.0
Industrial	Employee counts	61.50	61.50	61.50	61.50	0	0.0
Lg. Landscape	Total Population in 1000's	0.00	0.00	0.00	0.00	0	0.0

1. Based on compound interest function.

Table 4-14
Projected Average Daily Per Unit Water Use for the Unincorporated Areas

		Water Use in Gallons per Day per Counting Unit				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(1)
		Year					
Subsector	**Counting Unit**	**2000**	**2010**	**2020**	**2030**		
Single-Family	Housing units	644.41	653.56	663.93	665.35	3	0.1
Multifamily	Housing units	373.68	383.60	397.78	406.24	9	0.3
Commercial	Employee counts	116.82	115.12	115.12	115.12	-1	0.0
Industrial	Employee counts	47.92	47.92	47.92	47.92	0	0.0
Lg. Landscape	Total Population in 1000's	469.40	467.91	467.91	467.91	0	0.0

1. Based on compound interest function.

4.2.2 Comparison of Water Demand Projections with Independent Results

The water demand forecast for Paradise done with IWR-MAIN for this analysis was compared to one prepared by PID (Paradise Irrigation District 2000). As explained below, CDM conducted a second IWR-MAIN forecast for Paradise using alternative demographic projections. Figure 4-3 shows all three forecasts.

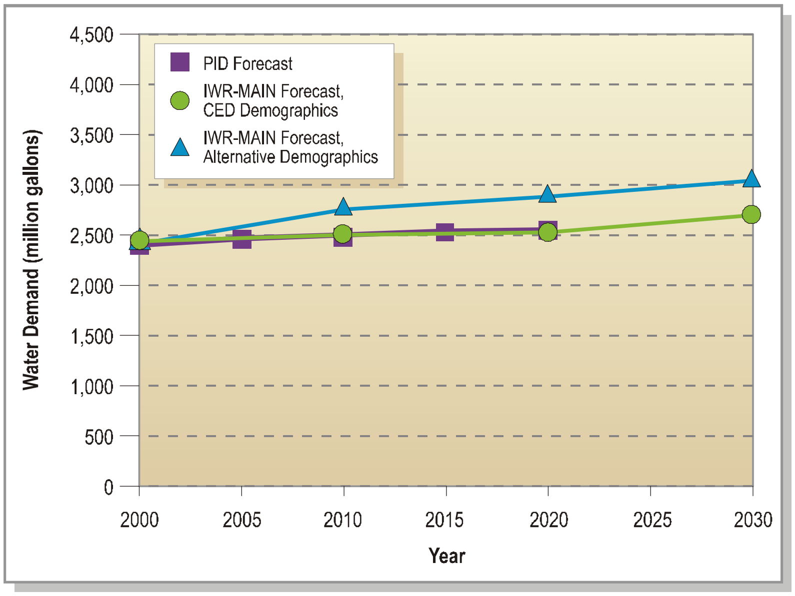

Figure 4-3
Comparison of Total Water Demand Projections for Paradise

Paradise city planning staff provided information for the alternative demographic projections (McGreehan 2003). Table 4-15 shows the results of the alternative demographics projections. The main difference is that these new demographic projections are based on an average annual growth rate of 1.0 percent per year to 2010 and 0.8 percent per year to 2030, whereas the CED projection population has an average annual growth rate of 0.3 percent. For the alternative demographic projections, CDM increased the housing units for both residential subsectors so that the alternative population projection would equal the population calculated by multiplying the persons per household by the number of housing units. For forecasted years for the alternative demographics, CDM changed the persons per household values from the base year by the same rates as did the CED for both subsectors.

Table 4-15
Alternative Demographic Projections for Paradise

Median Projection Demographic Data	Year				2000-2030 Total % Change	2000-2030 Ave. % Change per Year(2)
	2000	2010	2020	2030		
Single-Family Housing Units	8,633	10,315	11,810	12,930	50	1.4
Multifamily Housing Units(1)	3,681	4,398	5,036	5,513	50	1.4
Industrial Jobs	1,025	971	907	847	-17	-0.6
Commercial Jobs	6,433	6,830	7,150	7,484	16	0.5
Population	26,310	29,063	31,473	34,084	30	0.9
Median Income (Year-2000 dollars)	$31,863	$33,570	$35,369	$37,265	17	0.5
Persons per household, Single-Family	2.23	2.07	1.93	1.79	-20	-0.7
Persons per household, Multifamily	1.60	1.60	1.66	1.73	13	0.4
Housing Density Single-Family (units/acre)	3	3.06	3.17	3.27	8	0.2
Housing Density Multifamily (units/acre)	10	10	10.02	10.03	0.3	0.0

1. Includes housing units for the category *other*.
2. Based on compound interest function.

In comparing the water demand forecasts for Paradise, the IWR-MAIN forecast using the CED demographic projections is very similar to the PID water demand forecast. PID serves a few hundred accounts outside of the incorporated boundaries; this difference would not cause a significant difference in total water use between PID and the town of Paradise. The IWR-MAIN forecast using the alternative demographic projections is very different than the other two demand forecasts. The main difference is the assumed rate of growth for the alternative demographic projections. The CED demographic projections are based on slower rates of growth because the CED accounted for Paradise being nearly built out to its general plan. The extra water demand projected using the alternative demographic projections would be about 1 percent of the total water demand projected for the entire county.

The water demand forecast for Chico with IWR-MAIN for this analysis was compared to an analysis done by Cal Water done in 2002 (California Water Service Company, 2002). Figure 4-4 shows this comparison.

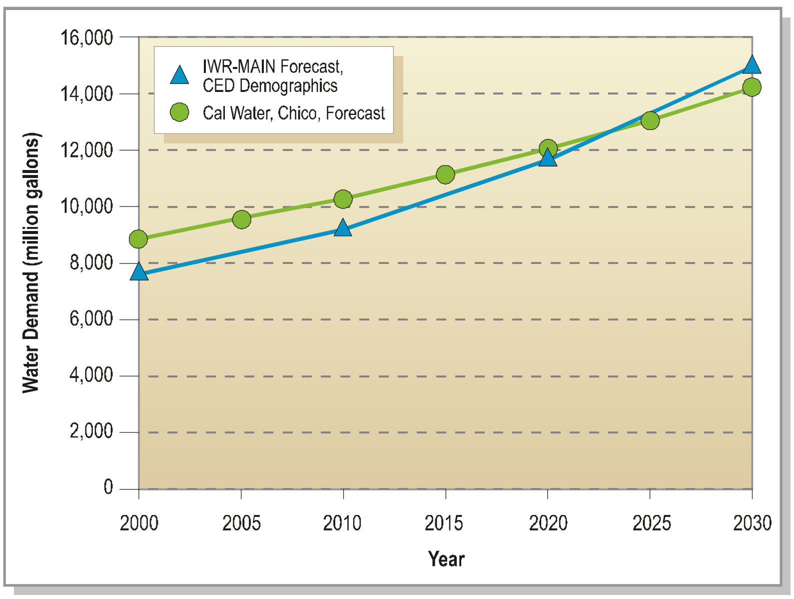

Figure 4-4
Comparison of Water Demand Projections for Chico
Projections for Paradise

The IWR-MAIN forecast has a lower total water use for the base year 2000. This difference occurs because the Cal Water accounts for water use outside the incorporated boundaries of Chico; the IWR-MAIN forecast accounts for water use outside of Chico in the unincorporated areas study area.

By the end of the forecast in 2030, however, the IWR-MAIN projected water demand is higher than the Cal Water projected water demand. The main reason for this difference is that the IWR-MAIN is based on demographic projections with higher rates of growth for Chico. For example, the average rate of growth from 2000 to 2030 for single-family units is 2.5 percent per year for this analysis; for its forecast, Cal Water assumed an average growth rate of 2.1 percent per year in single-family accounts. Also, the average rate of growth from 2000 to 2030 for single-family units is 1.7 percent per year for this analysis; Cal Water assumed an average decline of 0.08 percent per year in multifamily accounts.

Another reason for the differences in the forecasts is that two different forecasting methods were used. Cal Water used a per account projection method, while this analysis used an adjusted rate method. The adjusted rate method is able to account for the effects of economic factors on water use, which the per account method does not.

An estimate of urban water demand for Butte County was made in the *Water Inventory and Analysis Report* (Butte County Department of Water and Resource Conservation 2001). In this report, Butte County estimated that the urban water demand for the entire county in 1997 was 20,463 million gallons (62,800 acre-feet). For the current study, CDM estimated water demand for the entire county at 21,896 million gallons in the year 2000. Different methods were used for each study, but the sources of data were similar.